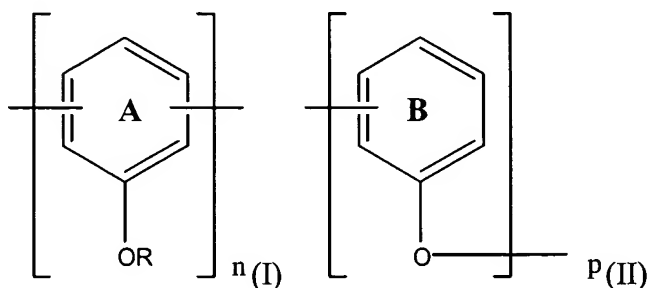


CLAIMS

What is claimed is:

- 5 1. A method of inhibiting oxidation of a substance, comprising the step of contacting said substance with a substituted benzene antioxidant polymer, wherein every repeat unit of the polymer is an antioxidant.
2. A method of inhibiting oxidation of a substance, comprising the step of
10 contacting said substance with a substituted benzene antioxidant polymer, wherein the polymer includes at least two polymerized substituted benzene monomers wherein the polymerized substituted benzene monomers are directly connected by a C-C or C-O-C bond.
- 15 3. The method of Claim 1, wherein the substituted benzene antioxidant polymer includes one or more hydroxyl or ester moieties per benzene.
4. A method of inhibiting oxidation of a substance, comprising the step of contacting said substance with a polymer that includes repeat units represented
20 by one or both of Structural Formulas (I) and (II):



wherein:

R is -H or a substituted or unsubstituted alkyl, acyl or aryl group;

Ring A is substituted with at least one *tert*-butyl group, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted

alkylenedioxy group, or substituted or unsubstituted n-alkoxycarbonyl group and zero, one or more additional functional groups; and

Ring B is substituted with at least one -H, at least one *tert*-butyl group, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted
5 alkylenedioxy group, or substituted or unsubstituted n-alkoxycarbonyl group and zero, one or more additional functional groups;

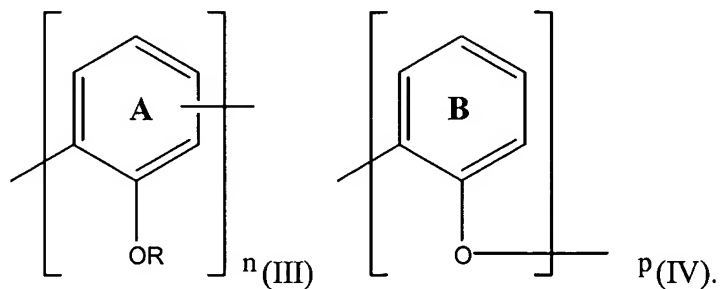
n is an integer equal to or greater than 2; and

p is an integer equal to or greater than 0, and

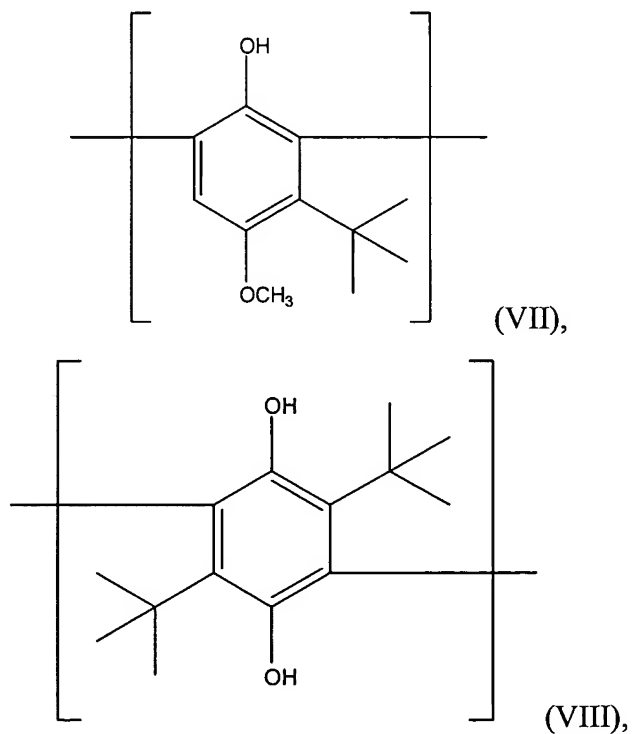
wherein the polymer includes at least two repeat units represented by one or
10 both of Structural Formulas (I) and (II) wherein the repeat units represented by one or both of Structural Formulas (I) and (II) are directly connected by a C-C or C-O-C bond between benzene rings.

5. The method of Claim 4, wherein Ring A and Ring B are each substituted with at
15 least one *tert*-butyl group.
6. The method of Claim 4, wherein Ring A and Ring B are each substituted with at least one substituted or unsubstituted alkylenedioxy group.
- 20 7. The method of Claim 6, wherein the alkylenedioxy group is a methylenedioxy group.
8. The method of Claim 4, wherein the additional functional groups are selected from the group consisting of -OH, -NH, -SH, a substituted or unsubstituted alkyl
25 or aryl group, a substituted or unsubstituted alkoxycarbonyl group, a substituted or unsubstituted alkoxy group and a saturated or unsaturated carboxylic acid group.

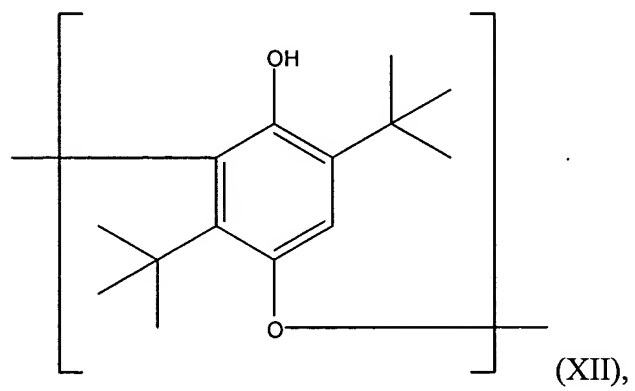
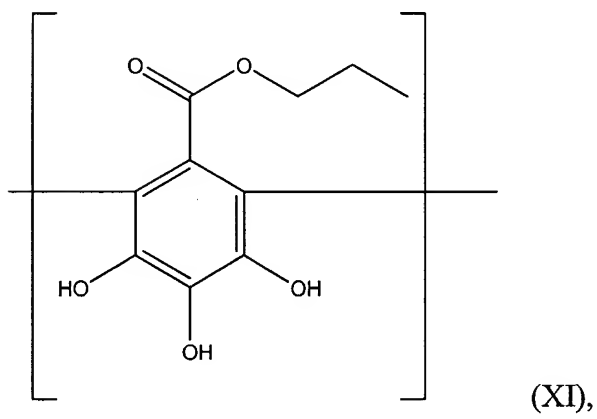
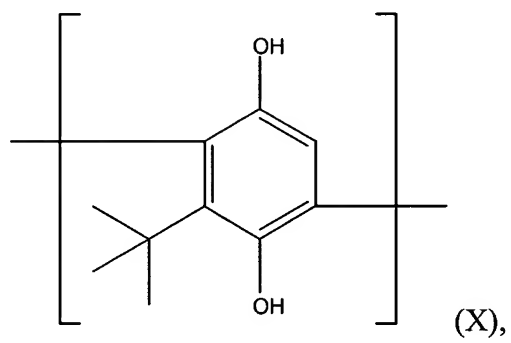
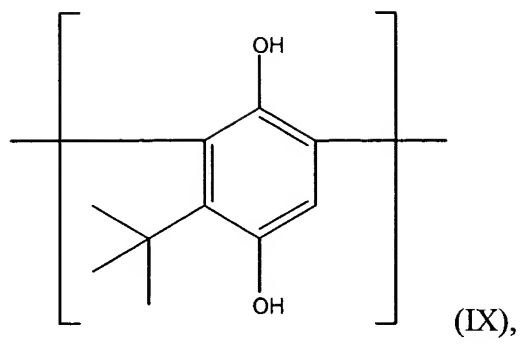
9. The method of Claim 8, wherein the additional functional groups are selected from the group consisting of $-OH$, a substituted or unsubstituted alkoxy group and a saturated or unsaturated carboxylic acid group.
- 5 10. The method of Claim 4, wherein the polymer includes repeat units represented by one or both of Structural Formulas (III) and (IV):



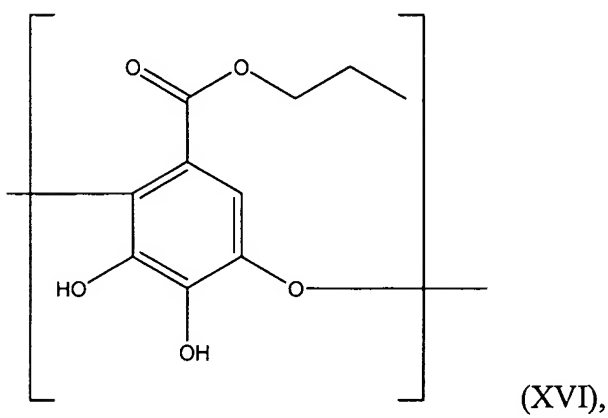
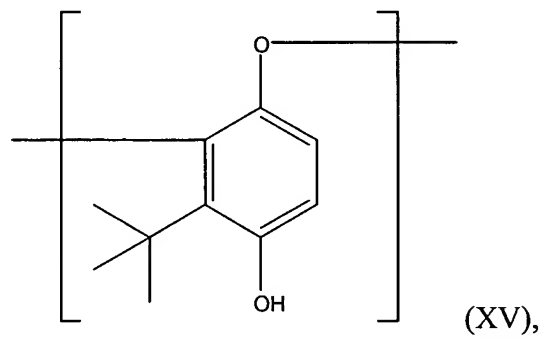
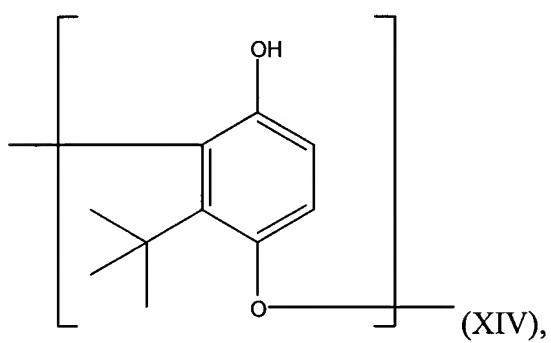
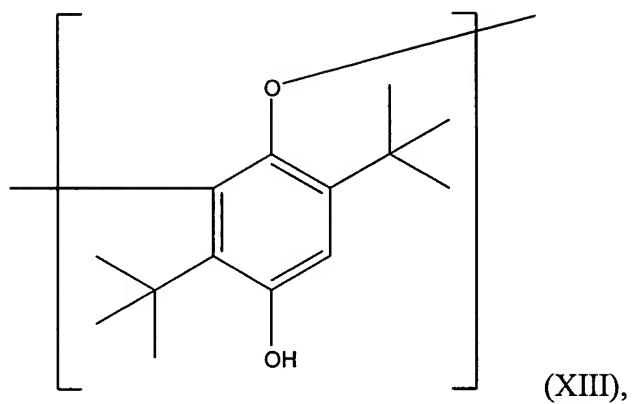
11. The method of Claim 4, wherein the polymer includes at least one repeat unit selected from the group consisting of:
- 10



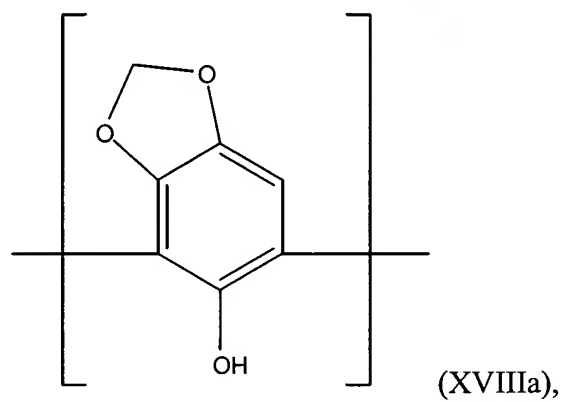
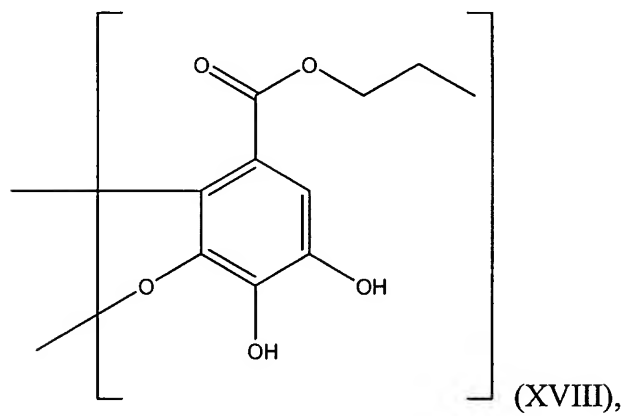
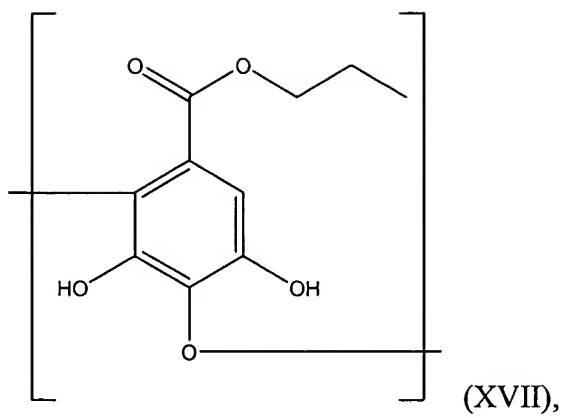
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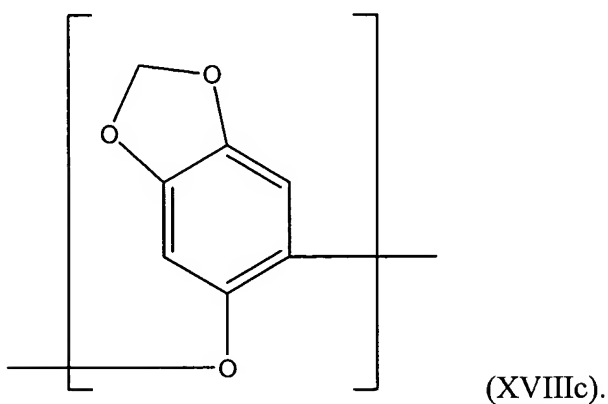
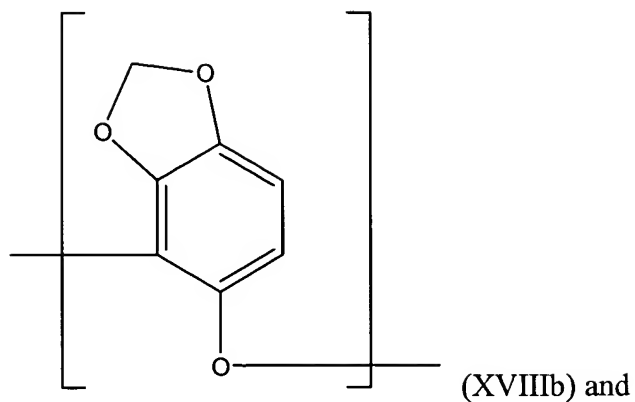
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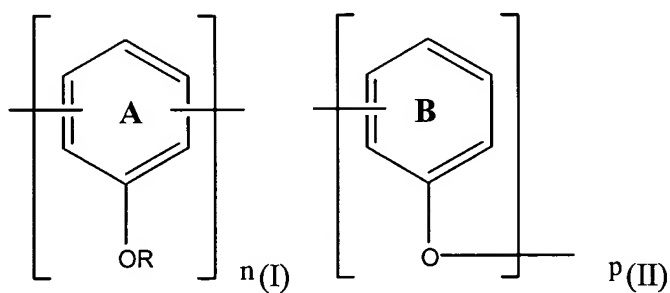
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-47-



12. An antioxidant polymer, comprising repeat units that include one or both of
5 Structural Formulas (I) and (II):



R is -H or a substituted or unsubstituted alkyl, acyl or aryl group;

- 10 Ring A is substituted with at least one *tert*-butyl group ortho to a hydroxyl or acyloxy group, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted alkylenedioxy group, or substituted or unsubstituted n-alkoxycarbonyl group and zero, one or more additional functional groups;

Ring B is substituted with at least one –H and at least one *tert*-butyl group ortho to a hydroxyl or acyloxy group, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted alkylenedioxy group, or substituted or unsubstituted n-alkoxycarbonyl group and zero, one or more additional functional groups;

n is an integer equal to or greater than 2; and

p is an integer equal to or greater than 0,

(1) wherein the polymer includes at least two repeat units represented by one or both of Structural Formulas (I) and (II) wherein the repeat units represented by one or both of Structural Formulas (I) and (II) are directly connected by a C-C or C-O-C bond between benzene rings, or wherein each repeat unit of the polymer is an antioxidant, and

(2) wherein polymers not including any repeat units represented by Structural Formula (I) are substituted on Ring B with one or more hydroxyl or acyloxy groups.

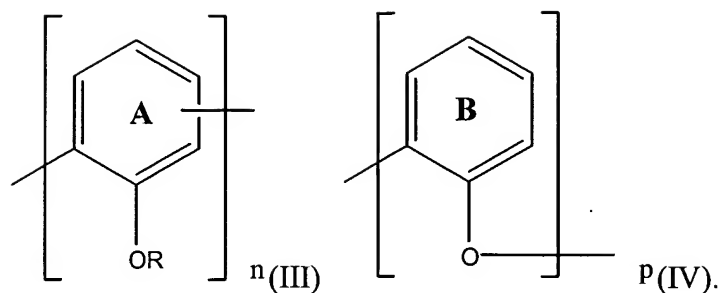
13. The antioxidant polymer of Claim 12, wherein Ring A and Ring B are each substituted with at least one *tert*-butyl group.

20 14. The antioxidant polymer of Claim 12, wherein Ring A and Ring B are each substituted with at least one substituted or unsubstituted alkylenedioxy group.

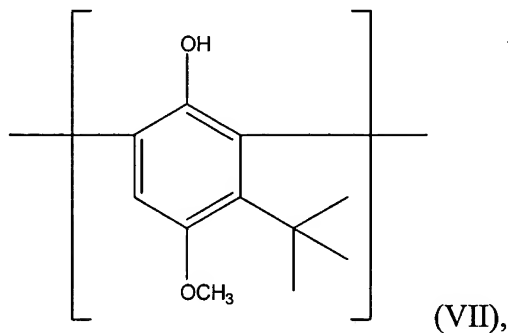
15. The antioxidant polymer of Claim 14, wherein the alkylenedioxy group is a methylenedioxy group.

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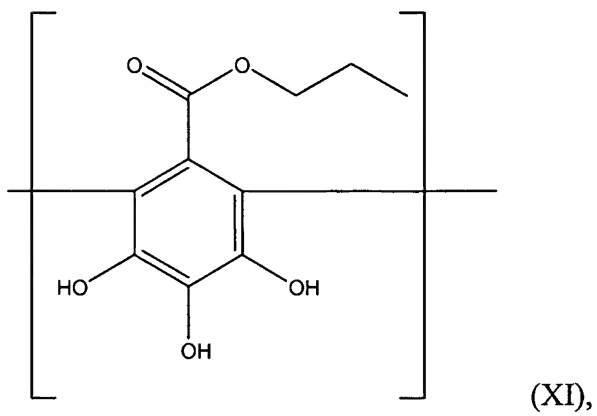
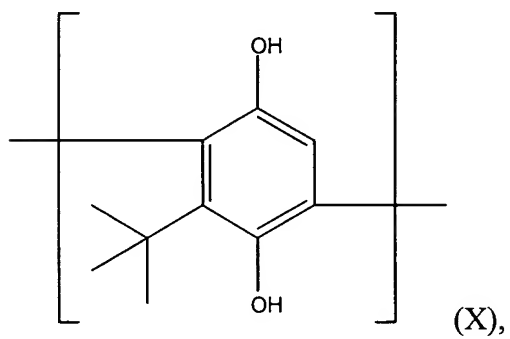
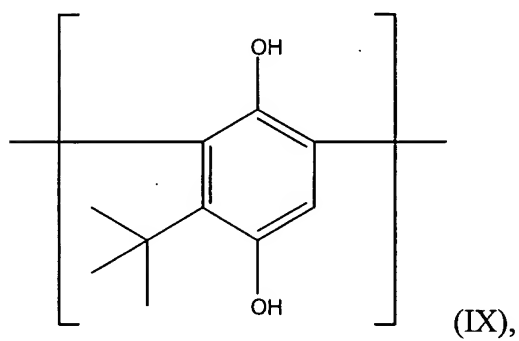
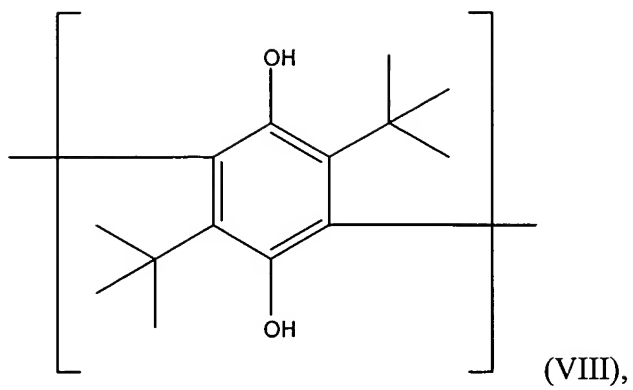
16. The antioxidant polymer of Claim 12, wherein the antioxidant polymer includes repeat units represented by one or both of Structural Formulas (III) and (IV):



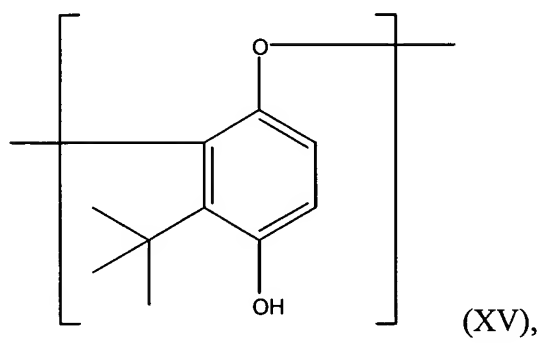
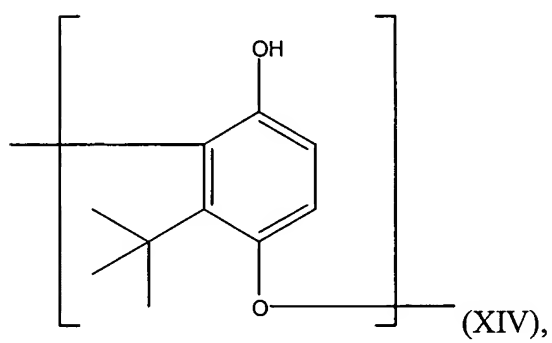
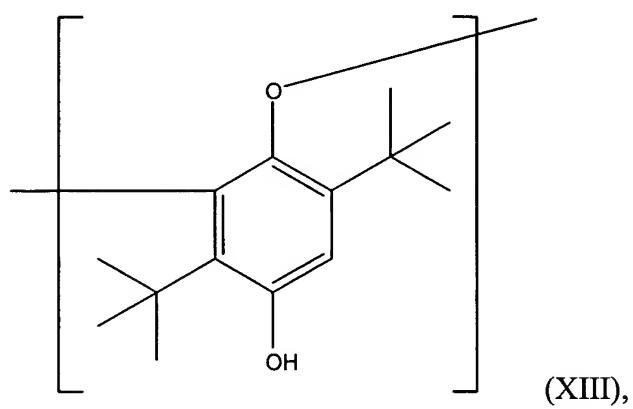
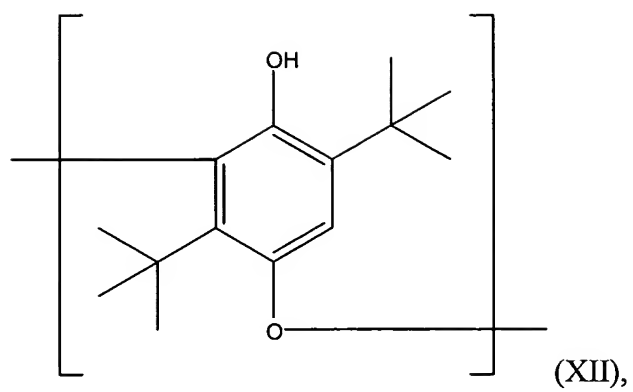
17. The antioxidant polymer of Claim 12, wherein the additional functional groups are selected from the group consisting of -OH, -NH, -SH, a substituted or unsubstituted alkyl or aryl group, a substituted or unsubstituted alkoxy carbonyl group, a substituted or unsubstituted alkoxy group and a saturated or unsaturated carboxylic acid group.
18. The antioxidant polymer of Claim 12, wherein the additional functional groups are selected from the group consisting of -OH, a substituted or unsubstituted alkoxy group and a saturated or unsaturated carboxylic acid group.
19. The antioxidant polymer of Claim 12, wherein the antioxidant polymer includes at least one repeat unit selected from the group consisting of:



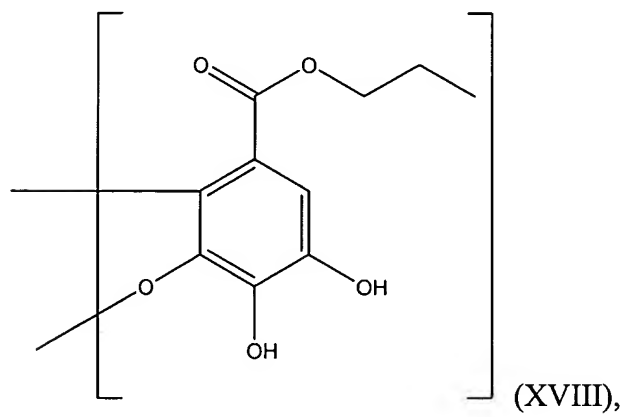
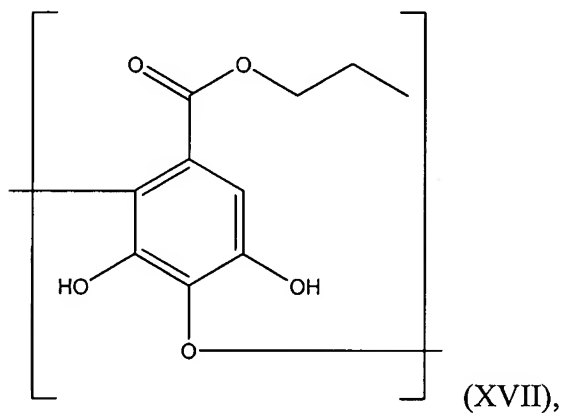
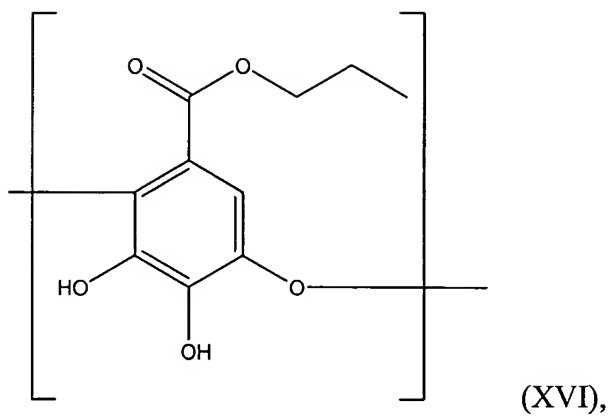
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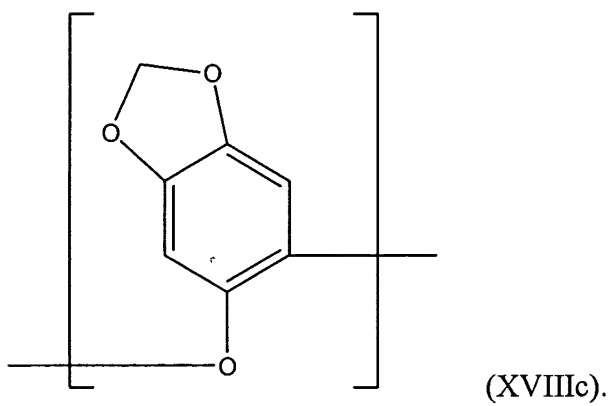
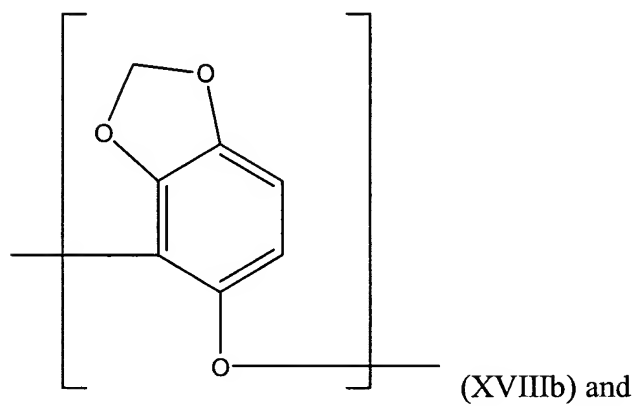
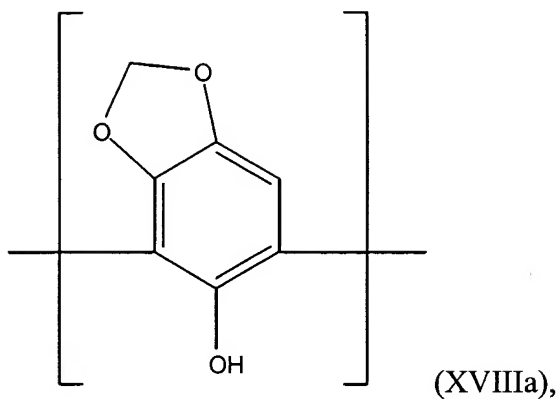
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-52-

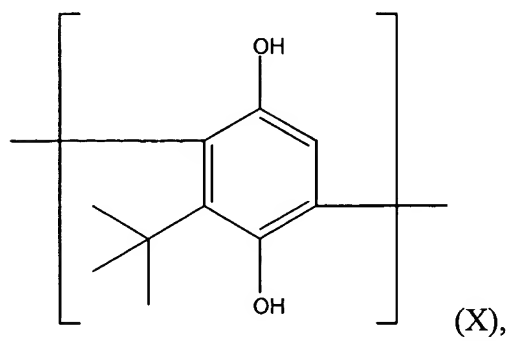
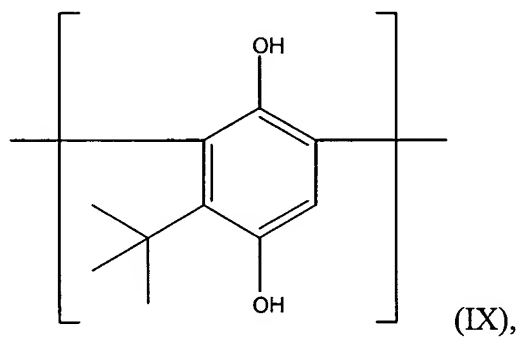
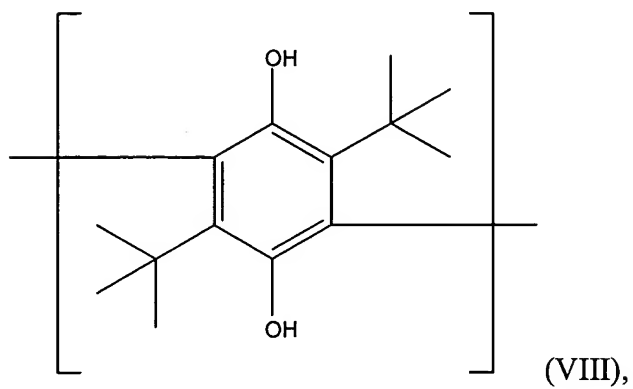
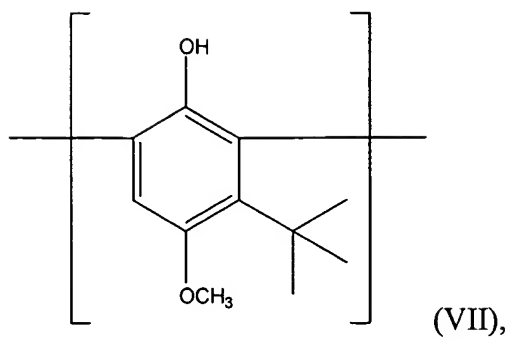


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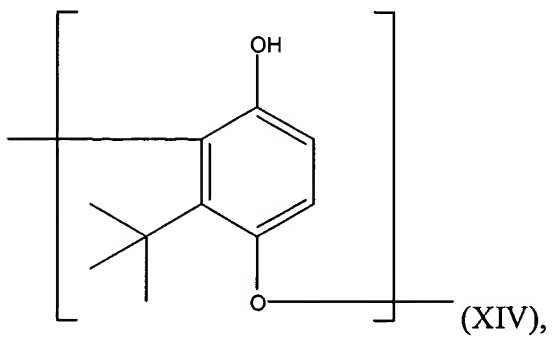
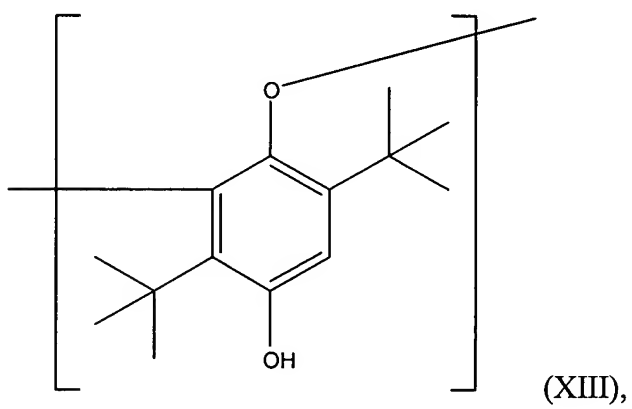
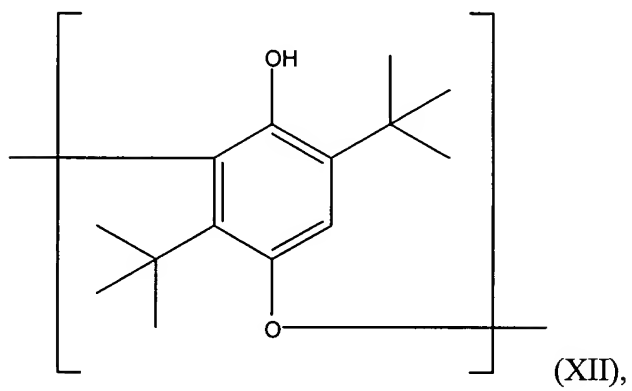
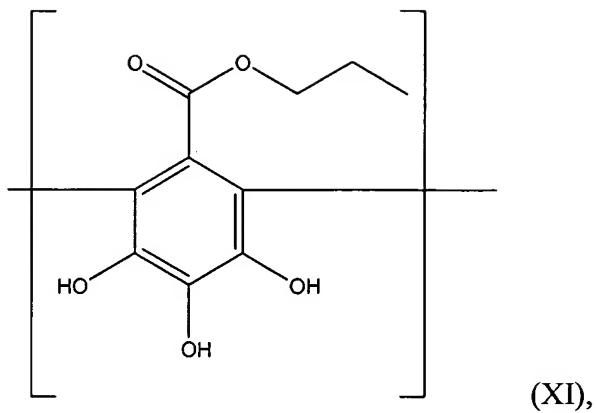


- 5 20. The antioxidant polymer of Claim 17, wherein the antioxidant polymer consists of repeat units selected from the group consisting of:

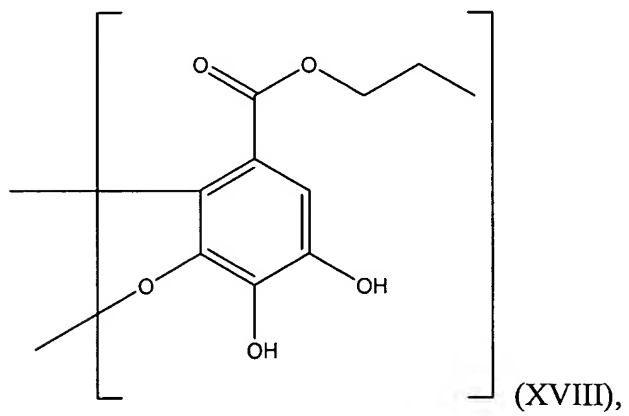
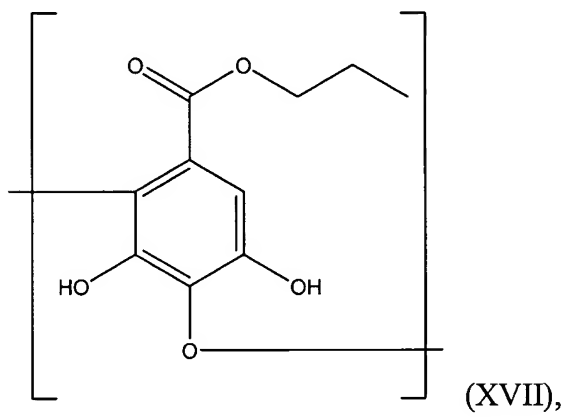
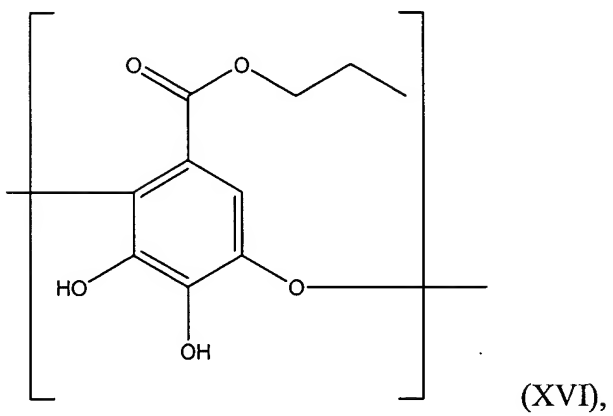
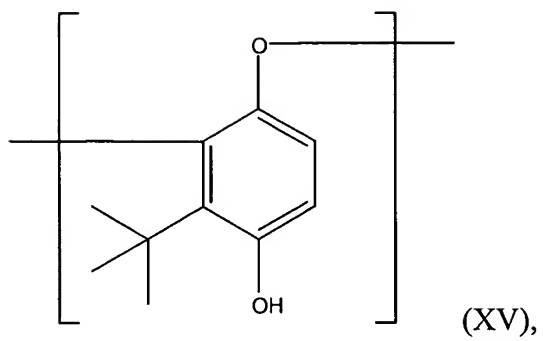
-54-



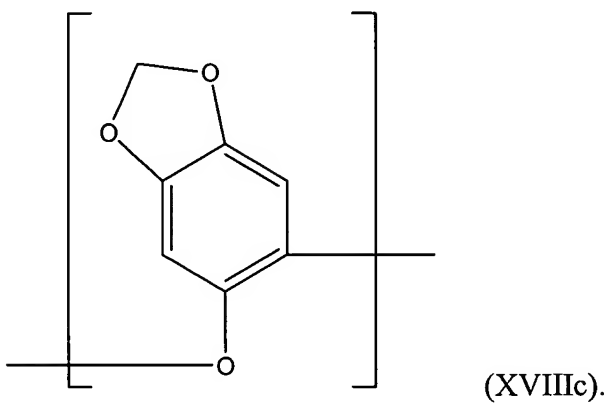
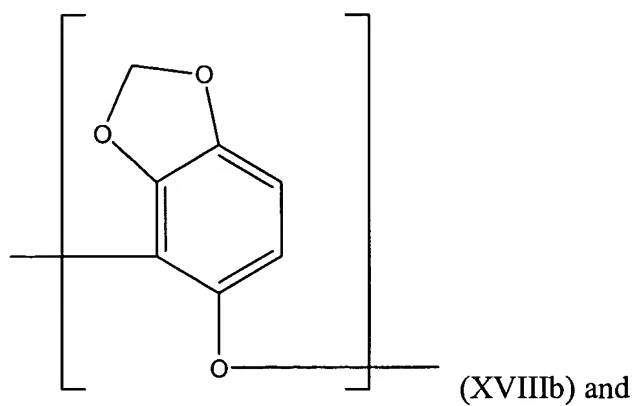
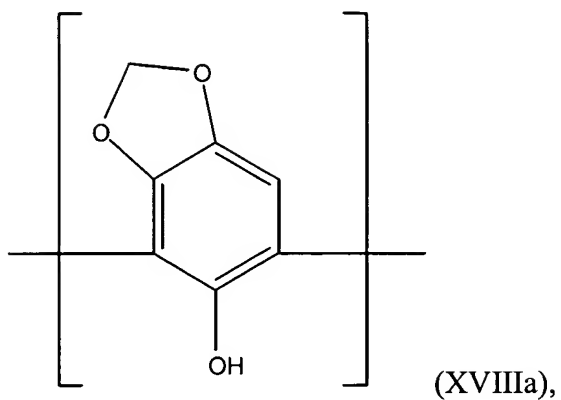
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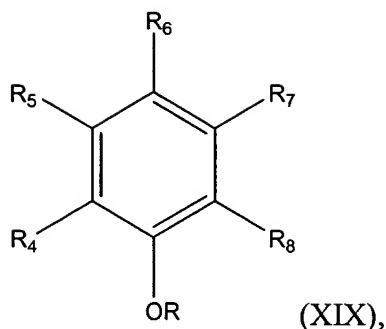


-57-



- 5 21. The polymer of Claim 20, wherein the polymer is poly(2-*tert*-butyl-4-hydroxyanisole).
22. A method of preparing an antioxidant polymer, comprising the step of polymerizing a monomer represented by Structural Formula (XIX):

-58-



wherein:

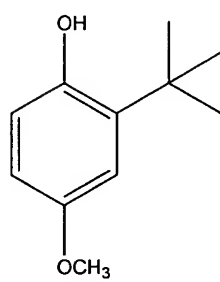
R is -H or a substituted or unsubstituted alkyl, acyl or aryl group; and
 R₄, R₅, R₆, R₇ and R₈ are independently -H, -OH, -NH, -SH, a
 substituted or unsubstituted alkyl or aryl group, a substituted or
 unsubstituted alkoxy carbonyl group, a substituted or unsubstituted
 alkoxy group or a saturated or unsaturated carboxylic acid group; or
 R₁, R₂, R₃, R₄ or R₅, in conjunction with an adjacent R₁, R₂, R₃, R₄ or R₅,
 forms a substituted or unsubstituted alkylendioxy group; and

provided that:

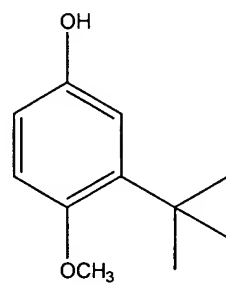
- (1) at least one of R₄, R₅, R₇ and R₈ is a *tert*-butyl group, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted alkylendioxy group, or substituted or unsubstituted n-alkoxy carbonyl group, and at least two of R₄, R₅, R₆, R₇ and R₈ are -H; or
- (2) at least one of R₄, R₅, R₇ and R₈ is a *tert*-butyl group, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted alkylendioxy group, or substituted or unsubstituted n-alkoxy carbonyl group, at least one of R₄, R₅, R₆, R₇ and R₈ is a hydroxyl, alkoxy carbonyl or aryloxy carbonyl group, and at least one of R₄, R₅, R₆, R₇ and R₈ is -H.

23. The method of Claim 22, wherein polymerization is catalyzed by an enzyme or an enzyme mimetic capable of polymerizing a substituted benzene compound in the presence of hydrogen peroxide.

24. The method of Claim 23, wherein the enzyme is a peroxidase, laccase, tyrosinase or lipase.
25. The method of Claim 23, wherein the enzyme mimetic is hematin, a tyrosinase-
5 model complex or a metal-salen complex.
26. The method of Claim 23, wherein the enzyme or enzyme mimetic is immobilized on a support.
- 10 27. The method of Claim 23, wherein the enzyme or enzyme mimetic is dispersed in a solution or suspension.
28. The method of Claim 22, wherein polymerization is catalyzed by a chemical method.
- 15 29. The method of Claim 28, wherein polymerization is catalyzed by iron chloride or a metallocene.
30. The method of Claim 28, wherein polymerization is catalyzed by an anionic
20 reagent.
31. The method of Claim 22, wherein the monomer includes at least one member selected from the group consisting of:

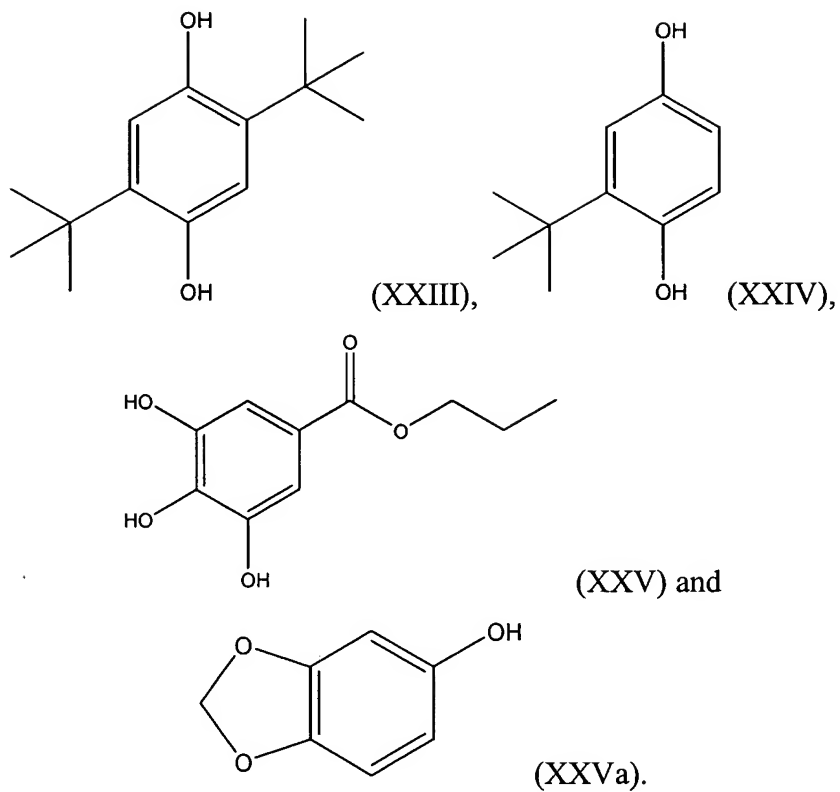


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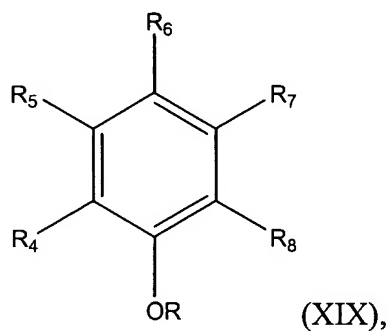


(XXI),

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- 5 32. A method of preparing an antioxidant polymer, comprising the step of polymerizing a monomer represented by Structural Formula (XIX):



wherein:

R is -H or a substituted or unsubstituted alkyl, acyl or aryl group; and
 10 R₄, R₅, R₆, R₇ and R₈ are independently -H, -OH, -NH, -SH, a substituted or unsubstituted alkyl or aryl group, or a substituted or unsubstituted alkoxy carbonyl group; and

provided that:

(1) at least one of R_4 , R_5 , R_7 and R_8 is a *tert*-butyl group or a substituted or unsubstituted alkoxy carbonyl group, and at least two of R_4 , R_5 , R_6 , R_7 and R_8 are $-H$; or

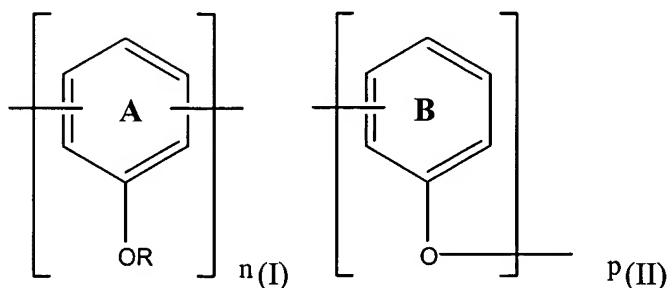
5 (2) at least one of R_4 , R_5 , R_7 and R_8 is a *tert*-butyl group or a substituted or unsubstituted alkoxy carbonyl group, at least one of R_4 , R_5 , R_6 , R_7 and R_8 is a hydroxyl, alkoxy, alkoxy carbonyl or aryloxy carbonyl group, and at least one of R_4 , R_5 , R_6 , R_7 and R_8 is $-H$.

10 33. The method of Claim 32, wherein polymerization is catalyzed by a chemical method.

34. The method of Claim 33, wherein polymerization is catalyzed by iron chloride or a metallocene.

15 35. The method of Claim 33, wherein polymerization is catalyzed by an anionic reagent.

20 36. A composition, comprising an edible product and an antioxidant polymer that includes repeat units represented by one or both of Structural Formulas (I) and (II):



wherein:

R is $-H$ or a substituted or unsubstituted alkyl, acyl or aryl group;

25 Ring A is substituted with at least one *tert*-butyl group, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted

alkylenedioxy group, or substituted or unsubstituted n-alkoxycarbonyl group and zero, one or more additional functional groups;

Ring B is substituted with at least one –H and at least one *tert*-butyl group, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted alkylenedioxy group, or substituted or unsubstituted n-alkoxycarbonyl group and zero, one or more additional functional groups;

n is an integer equal to or greater than 2; and

p is an integer equal to or greater than 0,

(1) wherein the polymer includes at least two repeat units represented by one or both of Structural Formulas (I) and (II) wherein the repeat units represented by one or both of Structural Formulas (I) and (II) are directly connected by a C-C or C-O-C bond between benzene rings, or wherein each repeat unit of the polymer is an antioxidant, and

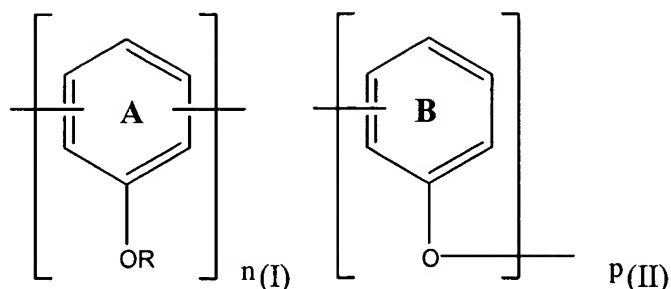
(2) wherein polymers not including any repeat units represented by Structural Formula (I) are substituted on Ring B with one or more hydroxyl or acyloxy groups.

37. The composition of Claim 36, wherein the edible product is an oil or contains an oil.

38. The composition of Claim 36, wherein the edible product is selected from the group consisting of cereals, beverages, chewing gum, crackers, potato flakes, bakery products and mixes, dessert mixes, meat products, flavorings, nuts, yeast and candies.

39. A composition for packaging, comprising a packaging material and an antioxidant polymer that includes repeat units represented by one or both of Structural Formulas (I) and (II):

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wherein:

R is -H or a substituted or unsubstituted alkyl, acyl or aryl group;

Ring A is substituted with at least one *tert*-butyl group, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted alkylenedioxy group, or substituted or unsubstituted n-alkoxycarbonyl group and zero, one or more additional functional groups;

Ring B is substituted with at least one -H and at least one *tert*-butyl group, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted alkylenedioxy group, or substituted or unsubstituted n-alkoxycarbonyl group and zero, one or more additional functional groups;

n is an integer equal to or greater than 2; and

p is an integer equal to or greater than 0,

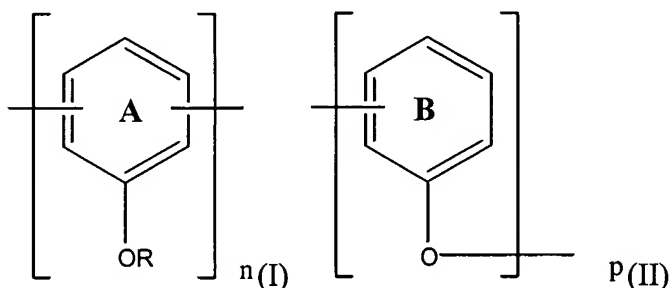
(1) wherein the polymer includes at least two repeat units represented by one or both of Structural Formulas (I) and (II) wherein the repeat units represented by one or both of Structural Formulas (I) and (II) are directly connected by a C-C or C-O-C bond between benzene rings, or wherein each repeat unit of the polymer is an antioxidant, and

(2) wherein polymers not including any repeat units represented by Structural Formula (I) are substituted on Ring B with one or more hydroxyl or acyloxy groups.

40. The composition of Claim 39, wherein the packaging material includes material selected from the group consisting of polymers, paper, cardboard and combinations thereof.

41. The composition of Claim 39, wherein the antioxidant polymer is blended with or mixed with the packaging material.
- 5 42. The composition of Claim 39, wherein the packaging material includes one or more polymers that are co-extruded with the antioxidant polymer.
43. The composition of Claim 42, wherein the packaging material includes a layer of an oxygen-resistant polymer or a mixture of oxygen-resistant polymers
10 between layers of moisture-resistant polymer or a mixture of moisture-resistant polymers, wherein the layers of moisture-resistant polymer are the same or different.
44. The composition of Claim 43, wherein the oxygen-resistant polymer or mixture
15 of oxygen-resistant polymers includes an ethylene-vinyl alcohol copolymer.
45. The composition of Claim 44, wherein the moisture-resistant polymer or mixture of moisture-resistant polymers includes polyethylene or polypropylene.
- 20 46. A composition comprising polyethylene and poly(2-*tert*-butyl-4-hydroxyanisole).
47. The composition of Claim 46, wherein the proportion of poly(2-*tert*-butyl-4-hydroxyanisole) is about 1 ppm to about 1,000 ppm.
25
48. The composition of Claim 47, wherein the proportion of poly(2-*tert*-butyl-4-hydroxyanisole) is about 10 ppm to about 100 ppm.
49. The composition of Claim 46, wherein the composition is a film.

50. The composition of Claim 46, wherein the composition is a pellet.
51. The composition of Claim 46, further comprising 2-*tert*-butyl-4-hydroxyanisole.
52. The composition of Claim 51, wherein the proportion of 2-*tert*-butyl-4-hydroxyanisole is about 1 ppm to about 1,000 ppm.
53. A composition, comprising an antioxidant polymer that includes repeat units represented by one or both of Structural Formulas (I) and (II):



wherein:

- R is -H or a substituted or unsubstituted alkyl, acyl or aryl group;
- Ring A is substituted with at least one *tert*-butyl group ortho, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted alkylenedioxy group, or substituted or unsubstituted n-alkoxycarbonyl group and zero, one or more additional functional groups;
- Ring B is substituted with at least one -H and at least one *tert*-butyl group, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted alkylenedioxy group, or substituted or unsubstituted n-alkoxycarbonyl group and zero, one or more additional functional groups;
- n is an integer equal to or greater than 2; and
- p is an integer equal to or greater than 0,

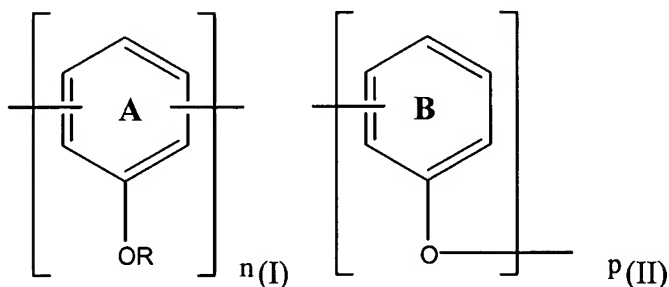
(1) wherein the polymer includes at least two repeat units represented by one or both of Structural Formulas (I) and (II) wherein the repeat units represented by one or both of Structural Formulas (I) and (II) are directly connected by a C-C or C-O-C bond between benzene rings, or wherein each repeat unit of the polymer is an antioxidant, and

(2) wherein polymers not including any repeat units represented by Structural Formula (I) are substituted on Ring B with one or more hydroxyl or acyloxy groups, and a member of the group consisting of synthetic or natural monomeric and oligomeric antioxidants, preservatives and combinations thereof.

54. The composition of Claim 53, wherein the proportion of the antioxidant polymer to synthetic or natural monomeric and oligomeric antioxidants, preservatives and combinations thereof is about 100:1 to about 1:100.

55. The composition of Claim 53, wherein the composition comprises about 0.1 ppm to about 10,000 ppm of the antioxidant polymer.

56. A composition, comprising one or more different antioxidant polymers that include repeat units represented by one or both of Structural Formulas (I) and (II):



wherein:

R is -H or a substituted or unsubstituted alkyl, acyl or aryl group;

Ring A is substituted with at least one *tert*-butyl group, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted alkylenedioxy group, or substituted or unsubstituted n-alkoxycarbonyl group and zero, one or more additional functional groups;

5 Ring B is substituted with at least one –H and at least one *tert*-butyl group, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted alkylenedioxy group, or substituted or unsubstituted n-alkoxycarbonyl group and zero, one or more additional functional groups;

n is an integer equal to or greater than 2; and

10 p is an integer equal to or greater than 0,

(1) wherein the polymer includes at least two repeat units represented by one or both of Structural Formulas (I) and (II) wherein the repeat units represented by one or both of Structural Formulas (I) and (II) are directly connected by a C-C or C-O-C bond between benzene rings, or wherein each repeat unit of the polymer is an antioxidant, and

15 (2) wherein polymers not including any repeat units represented by Structural Formula (I) are substituted on Ring B with one or more hydroxyl or acyloxy groups.

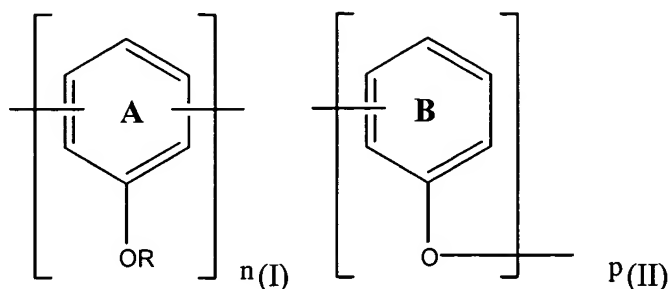
20 57. The composition of Claim 56, wherein at least one of the antioxidant polymers is a homopolymer.

58. The composition of Claim 56, wherein at least one of the antioxidant polymers is a copolymer.

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59. The composition of Claim 56, wherein at least one of the antioxidant polymers is a homopolymer and at least one of the antioxidant polymers is a copolymer.

60. A composition, comprising a cosmetic agent and an antioxidant polymer that includes repeat units represented by one or both of Structural Formulas (I) and (II):



5 wherein:

R is -H or a substituted or unsubstituted alkyl, acyl or aryl group;

Ring A is substituted with at least one *tert*-butyl group, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted alkylenedioxy group, or substituted or unsubstituted n-alkoxycarbonyl group and zero, one or more additional functional groups;

Ring B is substituted with at least one -H and at least one *tert*-butyl group, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted alkylenedioxy group, or substituted or unsubstituted n-alkoxycarbonyl group and zero, one or more additional functional groups;

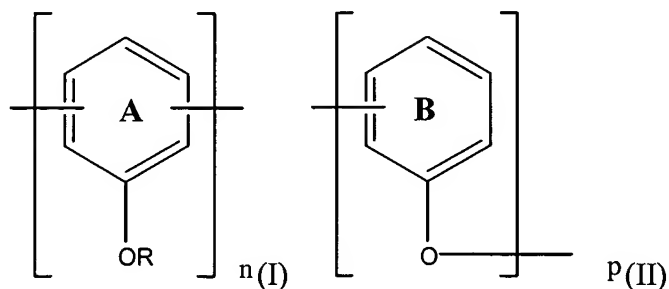
n is an integer equal to or greater than 2; and

p is an integer equal to or greater than 0,

(1) wherein the polymer includes at least two repeat units represented by one or both of Structural Formulas (I) and (II) wherein the repeat units represented by one or both of Structural Formulas (I) and (II) are directly connected by a C-C or C-O-C bond between benzene rings, or wherein each repeat unit of the polymer is an antioxidant, and

(2) wherein polymers not including any repeat units represented by Structural Formula (I) are substituted on Ring B with one or more hydroxyl or acyloxy groups.

61. The composition of Claim 60, wherein the composition comprises about 1% to about 20% by weight of the antioxidant polymer.
62. A pharmaceutical composition, comprising a pharmaceutically active agent and an antioxidant polymer that includes repeat units represented by one or both of Structural Formulas (I) and (II):



wherein:

R is -H or a substituted or unsubstituted alkyl, acyl or aryl group;

Ring A is substituted with at least one *tert*-butyl group, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted alkylendioxy group, or substituted or unsubstituted n-alkoxycarbonyl group and zero, one or more additional functional groups;

Ring B is substituted with at least one -H and at least one *tert*-butyl group, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted alkylendioxy group, or substituted or unsubstituted n-alkoxycarbonyl group and zero, one or more additional functional groups;

n is an integer equal to or greater than 2; and

p is an integer equal to or greater than 0,

(1) wherein the polymer includes at least two repeat units represented by one or both of Structural Formulas (I) and (II) wherein the repeat units represented by one or both of Structural Formulas (I) and (II) are directly connected by a C-C or C-O-C bond between benzene rings, or wherein each repeat unit of the polymer is an antioxidant, and

(2) wherein polymers not including any repeat units represented by Structural Formula (I) are substituted on Ring B with one or more hydroxyl or acyloxy groups.

- 5 63. The pharmaceutical composition of Claim 62, wherein the pharmaceutical composition is a liquid.
64. A method of preparing a phenolic polymer, comprising:
- 10 c) protecting at least one hydroxyl group of a substituted or unsubstituted phenol with a protecting group, wherein the substituted or unsubstituted phenol has at least one hydroxyl substituent, thereby obtaining one or more protected hydroxyl groups; and
- d) polymerizing the substituted or unsubstituted phenol, thereby obtaining the phenolic polymer.
- 15 65. The method of Claim 64, wherein the substituted or unsubstituted phenol is an antioxidant.
66. The method of Claim 64, wherein the one or more protected hydroxyl groups are independently at least one of a functional group selected from the group consisting of an ether, ester, silyl ether, carbonate, phosphinate, carbamate, sulfonate, nitrate, phosphoramidate, borate ester, phosphinothioyl ester and sulfenate.
- 20 67. The method of Claim 66, wherein the functional group is an ether or an ester.
68. The method of Claim 67, wherein the functional group is an ester.
69. The method of Claim 68, wherein the protecting group is an acetyl group.

70. The method of Claim 64, wherein the substituted or unsubstituted phenol is polymerized using an enzyme or an enzyme mimetic.
- 5 71. The method of Claim 70, wherein the enzyme or enzyme mimetic polymerizes the substituted or unsubstituted phenol in the presence of hydrogen peroxide.
72. The method of Claim 70, wherein the enzyme or enzyme mimetic is peroxidase, laccase, tyrosinase, lipase, hematin, a tyrosinase-model complex or a metal-salen complex.
- 10
73. The method of Claim 72, wherein the enzyme is peroxidase.
74. The method of Claim 64, wherein the substituted or unsubstituted phenol is polymerized using a chemical reagent or light.
- 15
75. The method of Claim 64, further including the step of removing at least a portion of the protecting groups after polymerizing the substituted or unsubstituted phenol.
- 20
76. The method of Claim 64, wherein the phenolic polymer is an antioxidant.
77. The method of Claim 64, wherein the phenolic polymer is electrically conductive.
- 25
78. A method of preparing a phenolic polymer, comprising:
- a) protecting two hydroxyl groups of an substituted or unsubstituted hydroquinone with protecting groups, thereby forming protected hydroxyl groups; and

b) polymerizing the substituted or unsubstituted hydroquinone, thereby obtaining the phenolic polymer.

5 79. The method of Claim 78, further including the step of deprotecting one of the two hydroxyl groups prior to polymerizing the optionally substituted hydroquinone.

10 80. The method of Claim 79, wherein the hydroquinone is substituted with a bulky alkyl group, whereby one hydroxyl group of the hydroquinone is proximal to the bulky group of the hydroxyl group and one hydroxyl group is distal to the bulky alkyl group.

15 81. The method of Claim 80, wherein the hydroxyl group distal to the bulky alkyl group is deprotected prior to polymerization.

82. The method of Claim 81, wherein the hydroxyl group distal to the bulky alkyl group is enzymatically deprotected.

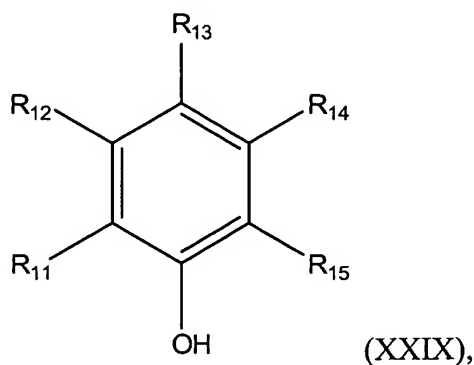
20 83. The method of Claim 82, wherein lipase deprotects the hydroxyl group.

25 84. The method of Claim 78, wherein the protected hydroxyl groups are functional groups independently selected from the group consisting of an ether, ester, silyl ether, carbonate, phosphinate, carbamate, sulfonate, nitrate, phosphoroamidate, borate ester, phosphinothioyl ester and sulfenate.

85. The method of Claim 84, wherein the functional groups are independently an ether or an ester.

86. The method of Claim 85, wherein the functional groups are both esters.

87. The method of Claim 86, wherein the protecting groups are both acetyl groups.
88. The method of Claim 78, wherein the substituted or unsubstituted hydroquinone
5 is polymerized using an enzyme or an enzyme mimetic.
89. The method of Claim 78, wherein the optionally substituted hydroquinone is polymerized using a chemical reagent or light.
- 10 90. The method of Claim 78, further including the step of removing at least a portion of the protecting groups after polymerizing the optionally substituted hydroquinone.
91. The method of Claim 78, wherein the phenolic polymer is an antioxidant.
- 15 92. The method of Claim 78, wherein the phenolic polymer is electrically conductive.
93. A method of preparing a phenolic polymer, comprising:
20 protecting with a protecting group at least one hydroxyl group of a monomer represented by Structural Formula (XXIX):



wherein:

R₁₁, R₁₂, R₁₃, R₁₄ and R₁₅ are independently -H, -OH, -NH, -SH, a substituted or unsubstituted alkyl or aryl group, a substituted or unsubstituted alkoxycarbonyl or aryloxycarbonyl group, a substituted or unsubstituted alkoxy group or a saturated or unsaturated carboxylic acid group; or

R₁₁, R₁₂, R₁₃, R₁₄ or R₁₅, in conjunction with an adjacent R₁₁, R₁₂, R₁₃, R₁₄ or R₁₅, forms a substituted or unsubstituted alkylenedioxy group;

provided that at least one of R₁₁, R₁₂, R₁₃, R₁₄ and R₁₅ is a *tert*-butyl group 1-ethenyl-2-carboxylic acid or ester thereof, a substituted or unsubstituted alkylene dioxy group or a substituted or unsubstituted n-alkoxycarbonyl group, at least one of R₁₁, R₁₂, R₁₃, R₁₄ and R₁₅ is a hydroxyl group, and at least one of R₁₁, R₁₂, R₁₃, R₁₄ and R₁₅ is -H; and polymerizing the monomer, thereby forming a phenolic polymer.

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94. The method of Claim 93, wherein one or more of R₁₂, R₁₄ and R₁₅ is a *tert*-butyl group.

95. The method of Claim 94, wherein R₁₁ is -H.

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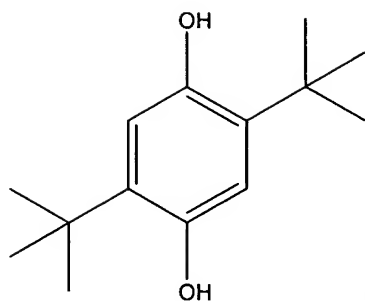
96. The method of Claim 95, wherein one or both of R₁₄ and R₁₅ are -H.

97. The method of Claim 96, wherein R₁₃ is -H, -OH or a substituted or unsubstituted alkyl group.

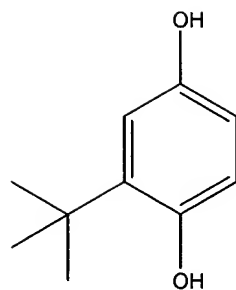
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98. The method of Claim 93, wherein the monomer includes at least one member selected from the group consisting of:

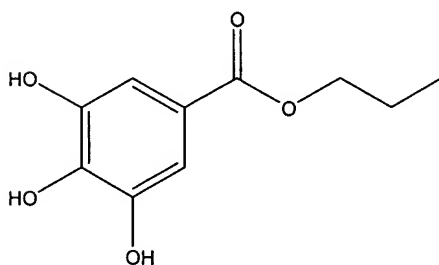
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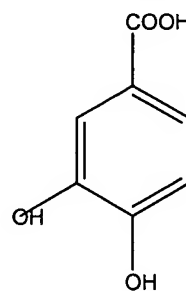
(XXXI),



(XXXII),

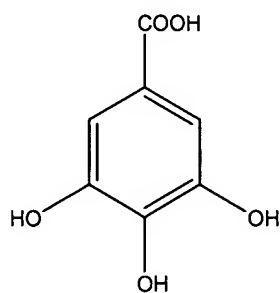


(XXVI),



(XXVII)

and



(XXVIII).

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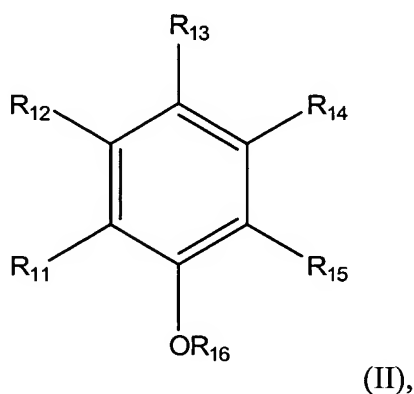
99. The method of Claim 93, wherein one of R_{11} , R_{12} , R_{13} , R_{14} and R_{15} is $-OH$ and wherein both hydroxyl groups are protected by protecting groups, whereby one hydroxyl group is distal to the *tert*-butyl group, 1-ethenyl-2-carboxylic acid or ester thereof, substituted or unsubstituted alkylendioxy group or substituted or unsubstituted n-alkoxycarbonyl group and one hydroxyl group is proximal to the *tert*-butyl group, 1-ethenyl-2-carboxylic acid or ester thereof, substituted or unsubstituted alkylendioxy group or unsubstituted n-alkoxycarbonyl group.
100. The method of Claim 99, wherein the hydroxyl group distal to the *tert*-butyl group, 1-ethenyl-2-carboxylic acid or ester thereof, substituted or unsubstituted

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alkylene dioxy group or substituted or unsubstituted n-alkoxycarbonyl group is deprotected prior to polymerization.

- 5 101. The method of Claim 100, wherein the hydroxyl group distal to the *tert*-butyl group, 1-ethenyl-2-carboxylic acid or ester thereof, substituted or unsubstituted alkylene dioxy group is enzymatically deprotected.
102. The method of Claim 101, wherein lipase deprotects the hydroxyl group.
- 10 103. The method of Claim 100, wherein the hydroxyl group distal to the *tert*-butyl group, 1-ethenyl-2-carboxylic acid or ester thereof, substituted or unsubstituted alkylene dioxy group is chemically deprotected.
- 15 104. The method of Claim 93, wherein the protecting group is an acyl group.
105. The method of Claim 104, wherein the protecting group is an acetyl group.
- 20 106. The method of Claim 93, wherein the monomer is polymerized using an enzyme or an enzyme mimetic.
107. The method of Claim 106, wherein the monomer is polymerized using a peroxidase.
- 25 108. The method of Claim 93, wherein the monomer is polymerized using a chemical reagent or light.
109. The method of Claim 93, further comprising the step of removing at least a portion of the protecting groups after polymerizing the monomer.

110. A method of preparing a phenolic polymer, comprising polymerizing a monomer represented by Structural Formula (XXX):



wherein:

- 5 R₁₆ is a protecting group; and
 R₁₁, R₁₂, R₁₃, R₁₄ and R₁₅ are independently -H, -OH, -NH, -SH, a substituted or unsubstituted alkyl or aryl group, a substituted or unsubstituted alkoxy carbonyl or aryloxy carbonyl group, a substituted or unsubstituted alkoxy group or a saturated or unsaturated carboxylic acid group; or
 10 R₁₁, R₁₂, R₁₃, R₁₄ or R₁₅, in conjunction with an adjacent R₁₁, R₁₂, R₁₃, R₁₄ or R₁₅, forms a substituted or unsubstituted alkylenedioxy group, thereby forming a phenolic polymer; and removing the protecting group.

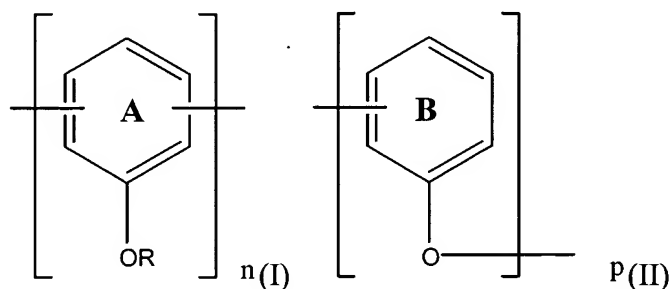
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111. A phenolic polymer, wherein the polymer includes substituted or unsubstituted phenol repeat units directly connected by C-C or C-O-C bonds, provided that at least 90% of the repeat units in the polymer are directly connected by C-C bonds.

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112. The phenolic polymer of Claim 111, wherein at least 95% of the repeat units in the polymer are directly connected by C-C bonds.

113. The phenolic polymer of Claim 112, wherein at least 98% of the repeat units in the polymer are directly connected by C-C bonds.
114. The phenolic polymer of Claim 113, wherein at least 99% of the repeat units in the polymer have are directly connected by C-C bonds.
115. The phenolic polymer of Claim 111, wherein the polymer is electrically conductive, is an optoelectronic polymer or both.
116. The phenolic polymer of Claim 111, wherein the polymer is an antioxidant.
117. The phenolic polymer of Claim 111, wherein the polymer has a molecular weight of from about 500 to about 1,000,000.
118. The phenolic polymer of Claim 117, wherein the polymer has a molecular weight of from about 1,000 to about 50,000.
119. A composition comprising an antioxidant polymer that includes repeat units represented by one or both of Structural Formulas (I) and (II):



wherein:

R is -H or a substituted or unsubstituted alkyl, acyl or aryl group;

Ring A is substituted with at least one *tert*-butyl group ortho, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted

alkylenedioxy group, or substituted or unsubstituted n-alkoxycarbonyl group and zero, one or more additional functional groups;

5 Ring B is substituted with at least one -H and at least one *tert*-butyl group, 1-ethenyl-2-carboxylic acid group or ester thereof, substituted or unsubstituted alkylenedioxy group, or substituted or unsubstituted n-alkoxycarbonyl group and zero, one or more additional functional groups;

n is an integer equal to or greater than 2; and

p is an integer equal to or greater than 0,

10 (1) wherein the polymer includes at least two repeat units represented by one or both of Structural Formulas (I) and (II) wherein the repeat units represented by one or both of Structural Formulas (I) and (II) are directly connected by a C-C or C-O-C bond between benzene rings, or wherein each repeat unit of the polymer is an antioxidant, and

15 (2) wherein polymers not including any repeat units represented by Structural Formula (I) are substituted on Ring B with one or more hydroxyl or acyloxy groups; and further including one or more petroleum products, one or more lubricants or one or more elastomers.